Answer **all** questions in this section in the spaces provided.

1. A sample of hydrated sodium carbonate has the formula $Na_2CO_3.xH_2O$. To determine its number of molecules of water of crystallization, x, 5.00 g of the hydrated salt was first dissolved in 250 cm^3 of deionised water. 25.0 cm^3 of the resultant solution was then pipetted out and titrated with 0.2 mol dm^{-3} of HC*l*.

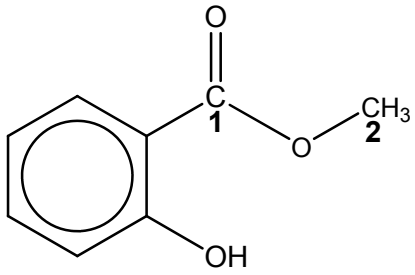
(a) Write a balanced equation of the reaction between anhydrous sodium carbonate and HC*l*. [1]

(b) If 20.00 cm^3 of HC*l* was required for the titration, determine the concentration of the anhydrous sodium carbonate in mol dm^{-3} and g dm^{-3}. [2]

(c) Determine the mass of water of crystallization present in 1 dm^3 of the hydrated sodium carbonate solution and hence the value of x. [2]

[Total: 5]

2. Oil of wintergreen is a common active ingredient in muscle rubs. It has the following structure.



(a) State the type of hybridisation of the carbon atoms, **C1** and **C2**. [2]

C1: _____ **C2:**_____

(b) State the shape and the bond angle around carbons **C1** and **C2**. [2]

Carbon	Shape	Bond angle
C1		
C2		

(c) Sketch the shape of one hybrid orbital of the carbon **C1**. [1]

[Total: 5]

3. (a) Ethanoic acid, CH_3CO_2H, is an organic acid. The table below shows the M_r values of the acid obtained in two different solvents.

Solvent	M_r of ethanoic acid
Water	60
Hexane	120

(i) Suggest an explanation for the above observations. [2]

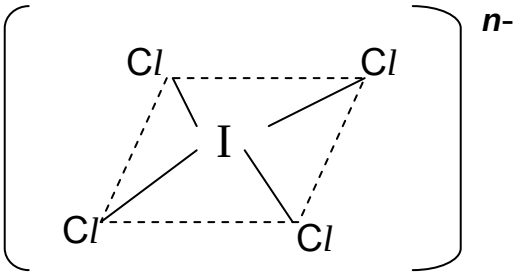
……..……

……...

……...

(ii) With the aid of a diagram, show the type of bonding present when ethanoic acid is dissolved in hexane. [1]

3. (b) Iodine and chlorine react to form a product which has a structure of a square planar.



Deduce the total number of electrons around the iodine atom and hence the value of ***n*** and the oxidation number of iodine in this ion. [2]

Total number of electrons around the iodine atom = ……

n = ……

Oxidation number of iodine = ……

[Total: 5]

4. Diamond and graphite are allotropes of carbon.

(a) Using the following data, construct an energy cycle to calculate the standard enthalpy change of reaction for the conversion of diamond to graphite.

C(diamond) $\rightarrow$ C(graphite) [3]

Reaction	**$\Delta H°$ / kJ mol^{-1}**
C(diamond) + $O_2(g) \rightarrow CO_2(g)$	-395.4
C(graphite) + ½ $O_2(g) \rightarrow$ CO(g)	-109.0
CO(g) + ½ $O_2(g) \rightarrow CO_2(g)$	-283.0

(b) By considering the structures of diamond and graphite, explain why the entropy change for the conversion of diamond to graphite is positive. [2]

……

……

……

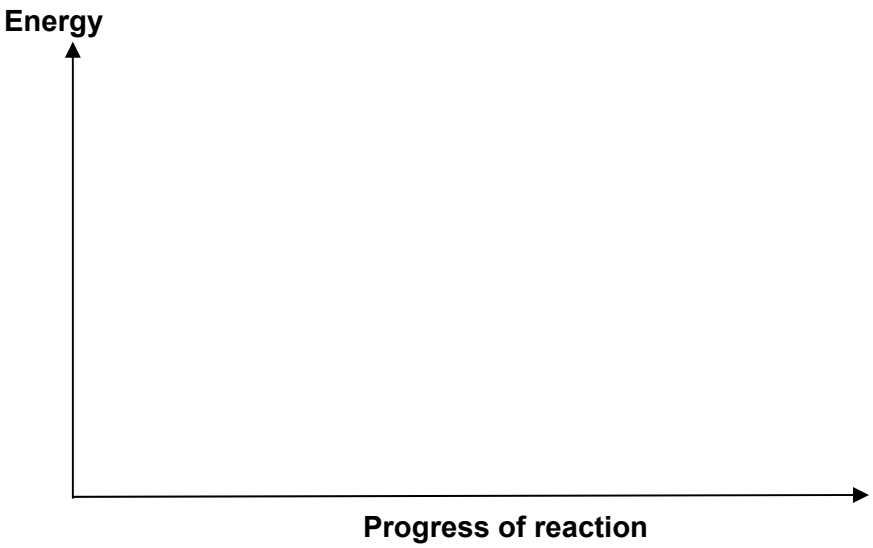
4. (c) Explain why the conversion of diamond to graphite is spontaneous at all temperatures. [2]

……

……

……

(d) Using the grid provided below, sketch an energy profile diagram of this conversion of diamond to graphite, given the activation energy for the reaction to be 726 kJ mol^{-1}. [1]



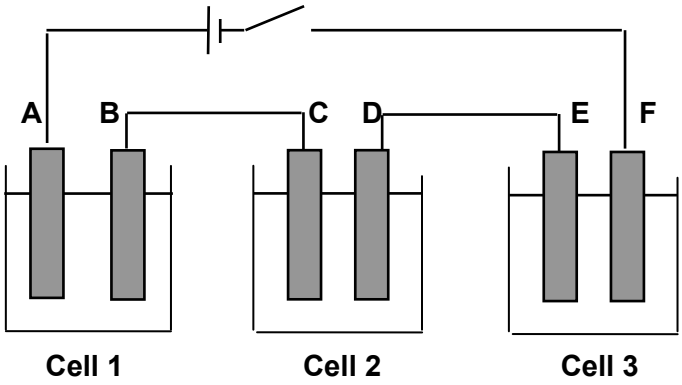
[Total:8]

5. A current is passed through three cells connected in series.

Cell 1 contains lead electrodes **A**, **B** and electrolyte $Pb(NO_3)_2$ (aq).

Cell 2 contains platinum electrodes **C**, **D** and electrolyte A*l*Br_3 (aq).

Cell 3 contains platinum electrodes **E**, **F** and electrolyte containing $\mathbf{X^{n+}}$ (aq).



(a) On closing the switch, give the ion-electron equations, including state symbols, for the reactions occurring at each of the electrodes, **A** to **D**. [4]

Electrode **A**:

……

Electrode **B**:

……

Electrode **C**:

……

Electrode **D**:

……

5. **(b)** It was found that 3240 coulombs of electricity cause the deposition of 1 g of **X** (A_r = 119.0) at electrode **F** in cell 3. Find the value of **n** in $\mathbf{X^{n+}}$ (aq). [2]

[Total: 6]

6. The solubility product of calcium hydroxide is 1.0×10^{-12} mol^3 dm^{-9}.
Calculate the solubility of calcium hydroxide in:

(a) water

(b) 0.10 mol dm^{-3} aqueous calcium sulfate

6. (c) Equal volumes of 1 x 10^{-3} mol dm^{-3} aqueous calcium nitrate, $Ca(NO_3)_2$, and 2 x 10^{-3} mol dm^{-3} of aqueous barium hydroxide, $Ba(OH)_2$, were mixed in a beaker. Predict if a precipitate of calcium hydroxide would form.

[Total: 6]

7. (a) Hydrogen halides can decompose at high temperatures according to the equation: $2HX(g) \rightarrow H_2(g) + X_2(g)$

The percentage of each halide that will undergo decomposition at 2000°C is shown in the following table:

Temperature / °C	**% of HX decomposed**			
	HF	**HCl**	**HBr**	**HI**
2000	6 x 10^{-5}	4 x 10^{-1}	4	30

Using relevant data from the *data booklet*, explain the trend above. [2]

……..

……..

……..

[Turn Over

7. (b) The following equation shows what happens when concentrated sulfuric acid is added to HI. [3]

$$8HI + H_2SO_4 \rightarrow H_2S + 4I_2 + 4H_2O$$

(i) Write an equation for the reaction between HBr and concentrated H_2SO_4.

……..

(ii) With reference to the change in oxidation state of sulfur, explain the differences in the reaction between HBr and HI with concentrated sulfuric acid.

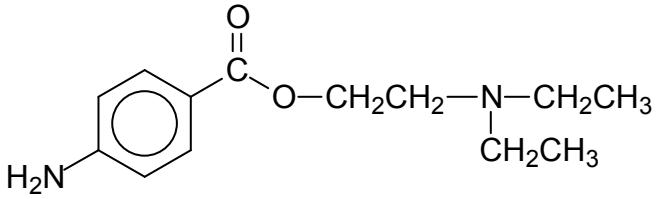
……

……

……

[Total: 5]

8. Procaine was the first injectable local anasthetic used to reduce pain in some dental and medical procedures. Procaine has the following structure:



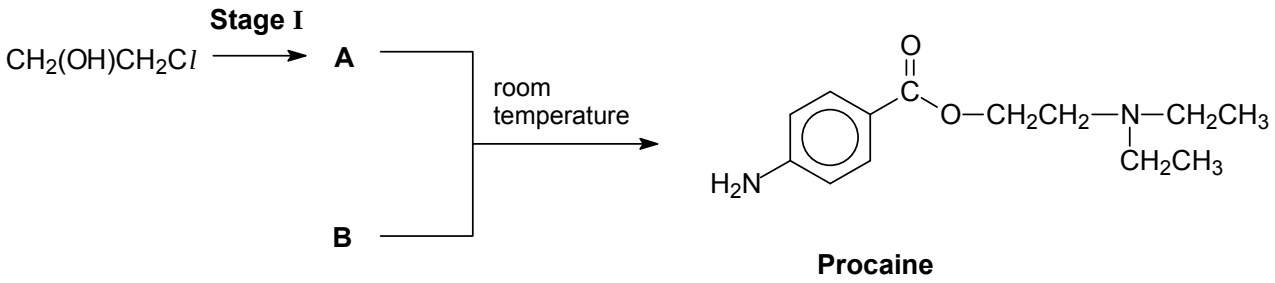
Procaine

(a) Name **2** functional groups present in Procaine. [3]

……

……

8. (b) Procaine can be synthesized from **A** and **B** by the following reaction pathway: [3]



Procaine

(i) Draw the structural formulae of the compounds **A** and **B**:

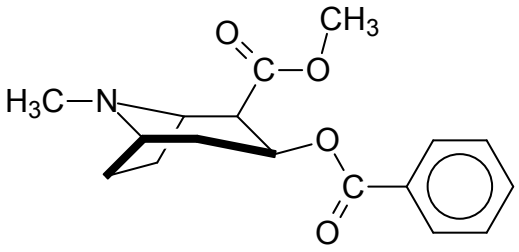
A	**B**

(b) (ii) State the reagent and condition used for **Stage I**.

Stage I:

Reagent and Condition: ……..

8. (c) Prior to the discovery of procaine, cocaine was the commonly used anaesthetic. Cocaine has the following structure. [4]



Cocaine

(i) Suggest one reagent and condition which will react with both procaine and cocaine to give the **same** observation.

Reagent and condition: ……..

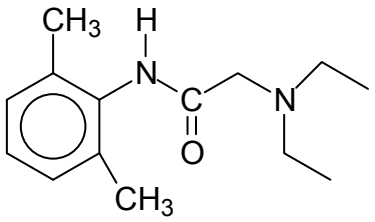
Observation: …….

(ii) Suggest one reagent and condition which will react with procaine and **not** with cocaine.

Reagent and condition: ……..

Observation: …….

8. (d) Procaine and cocaine are rarely used today since more effective alternatives such as lidocaine exists. Furthermore, adverse drug reactions to lidocaine are rare when administered correctly. Lidocaine has the following structure:



lidocaine

Draw the structural formula(e) of the organic product(s) formed when lidocaine is treated with:

(i) Aqueous HC*l* at room temperature	**(ii) Hot alkaline potassium manganate (VII) solution**

[3]

[Total: 13]

[Turn Over

9. Insulin is a peptide hormone composed of 51 amino acid residues. Insulin has extensive effects on metabolism and other body functions, such as vascular compliance. A section of the insulin can be digested with enzyme **X** and **Y** and the peptide fragments are shown below:

With enzyme X:
ASP-LYS-GLY-CYS
LYS-VAL-ARG
VAL-CYS

With enzyme Y:
GLY-CYS-LYS
VAL-ARG
VAL-CYS-ASP-LYS

(a) What is the possible primary structure of a section of insulin based on the information given above? [1]

……

(b) Insulin is used medically to treat diabetes mellitus. Suggest a reason why insulin medication must be stored in a cool environment. [2]

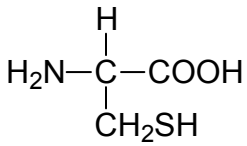
……

……

……

9. **(c)** The secondary structure of insulin exists largely as an alpha-helix. Sketch the essential features of the alpha-helix in insulin. [1]

(d) The tertiary structure of insulin is stabilised by disulfide linkages of the cysteine (CYS) residues.



Cysteine

With the aid of a diagram, show the disulfide linkages that are formed between the cysteine residues. [1]

9 **(e)** In the aqueous state, cysteine exists largely as zwitterions. With the aid of a diagram, describe how cysteine is soluble in water. [2]

[Total: 7]

-END OF PAPER-